NaviAR- An Augmented Reality based Navigation and guidance system

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***Abstract*—Today AR is changing the lifestyle of people by replacing the traditional approach/method that we use in our daily life. At present, there are many navigation systems present in the market which work on GPS, Bluetooth, RFID, etc. In this project, we are focusing on an indoor navigation system that is based on AR. The current Indoor navigation systems that are available in the market utilizes ultra-wideband (UWB), radio-frequency identification (RFID), and received signal strength (RSS) techniques that encompass WIFI, BLE, and other similar technologies. These systems typically require surplus infrastructure for their implementation, which results in significantly increased cost and complexity. Therefore, as a solution to reduce the level of cost and complexity, quick response (QR) codes and VI-SLAM (from google's AR Core) are utilized in this project to facilitate navigation with the assistance of a smartphone. The QR code helps to compensate for localization errors caused by the visual odometry algorithm, thereby providing more accurate localization. The proposed algorithm having IMU readings, SLAM and QR code shows a higher accuracy which is higher than existing indoor navigation techniques. Using QR codes users can relocate themselves in closed infrastructures like malls, office buildings, etc. with less effort interaction.**

***Index Terms*—Indoor navigation, QR codes, Augmented Reality (AR), Global Positioning System (GPS), Navmesh, Simultaneous Localization and Mapping (SLAM)**

I. Introduction

For centuries navigation has been developed from hand-drawn maps to compass to present-day GPS navigation. But when it comes to indoor navigation, it's not much developed and still relies on traditional techniques like physical maps pasted on a wall in certain areas, which is not necessarily very intuitive for people who are new to the area and not accustomed to the standards in the locality or the specific building. In today's world architectural and infrastructural growth is immense. and there are huge buildings and structural complexes, these overwhelm human navigation capabilities and are difficult to fit properly in the maps or guides. In an indoor position system, GPS signal is not used as Gps signal is based on satellite signal which is unreachable in indoor applications. Alternate positioning systems that exist can be categorized in 2 groups namely sensor-based, and signal network-based. Sensor-based indoor navigation system utilizes sensor systems like sonar lidar radar or visual odometry system for navigation. This system is very accurate for only local navigation for small single leveled well separated infrastructure. As it can easily get confused for similar types of infrastructure as it doesn't have unique identification. Signal-based indoor navigation systems these systems generally use wireless network beacons which mimic satellites in the GPS. Wireless networks used are the ultra-wideband, RSS, indoor GPS, BLE, and wifi nodes. These nodes are placed in a unique location and emit signals just like GPS satellites. This system has two flaws: it requires continuous maintenance and is very hard to set up and it has good precision but bad accuracy. To overcome this we have designed a navigation app based on Augmented Reality with a positioning system that is a mix of Google's AR Core which uses Visual SLAM and QR Codes which helps in decreasing the initial costs and setup hassle without compromising on accuracy. The goal is to resolve the confusion and navigation problems of huge structural places like malls and airports.

II. Challenges faced in existing methods

QR codes serve as a passive land marking tool rather than a beacon system. The disadvantage of beacon systems is their high installation costs. Another issue that arises is constant maintenance because these beacons is battery-driven, this system should be checked on a regular basis for proper operation. As a result, they might switch off as the battery runs out. This random turnoff might create a chaotic environment in the system, resulting in signal loss. QR codes shine here since once they are setup in the appropriate locations, since their indexed landmarks are all stored in a database in the mobile app, there is no chance of environmental factors affecting the performance. The QR code acts as an indexed landmark point

that may be scanned in the camera feed to obtain an accurate position since these markers are indexed and marked according to the location kept in the database on the app. While using visual SLAM when the camera feed gets interrupted and the location tracking doesn't work well, scanning the nearest QR code will enable to quickly relocate the user in the global map. In this way, QR codes aid in local and global positioning on building maps, allowing for precise location.

III. System Requirements

A. Development system configuration

TABLE I
DEVELOPMENT SYSTEM CONFIGURATIONS

Sr. No	*Parameters*	*Specification*
1	Operating System	Windows 7 (SP1+) and Windows 10, 64-bit versions only / Mac OS Sierra 10.12.6+
2	CPU	X64 architecture with SSE2 instruction set support (Intel Core i5 or better)
3	RAM recommended	4 GB RAM minimum, 8 GB
4	Graphics API	DX10, DX11, and DX12-capable GPUs (NVidia or AMD)
5	Free Disk Space	80GB of free disk space

B. User system configuration

Android devices should support ARCore via Google Play Services for AR, which allows for the creation of augmented reality (AR) experiences using an AR Core SDK. On compatible devices, Google Play Services for AR is accessible via the Google Play Store. AR Core needs the following:
1. Android 7.0 or later (some models require newer versions as noted below)
2. A gadget that came preloaded with the Google Play Store.

IV. Software Used

A. Unity

Unity is a development engine created by Unity Technologies. The engine has a wide range of plugins as well as SDK and API support, which aids in the building of apps. It is particularly popular for 3D rendering because to its industry-leading engines. The engine may be used to construct Virtual Reality or Augmented Reality scenarios and apps, as well as interactive simulations and other 3D and 2D experiences. We utilize the engine for its best in class industrial VR and AR SDKs. Unity is well-known in the game development business.

B. Google AR Core

AR Core is Google's platform to build Augmented Reality applications, it uses different set of APIs to perform fundamental tasks for any AR application. It achieves motion tracking using sensor fusion between visual Simultaneous Localization And Mapping (SLAM) and IMU readings of the phone. It also understands the environment and surfaces in the image frames by doing detecting feature points so that it can recognise surfaces on which the virtual figures need to be drawn. It can obtain depth maps using RGB cameras on the phone in some supported list of devices it helps to visualise collisions and other 3D interactions.

C. Visual Studio code

Microsoft's Visual Studio is a source code editor that is widely used for coding. Visual Studio is fully compatible, with Linux, and macOS. The primary usage of Visual Studio is for coding applications like as debugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and integrated Git. The finest aspect is that it has excellent unity support; it is the best Unity companion for developing C files. While Unity has mutual support for it and recognizes it as an external script editor by default.

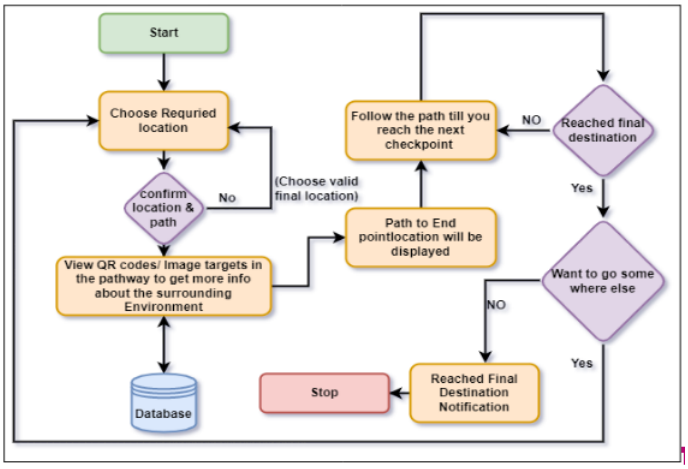

Fig. 1. Application flowchart

V. Methodology

A. Navmesh

Unity has a built-in component called navmesh. It is used for mesh generation for pathfinding. Using this component, the developer can define the walkable path for the navmesh agent in the 3D map. So in our case the user is our agent who will be walking through the 3D map. Navmesh can find the most optimized shortest path to the required destination. Even if the 3D map has moving objects in it navmesh can easily find the shortest path to the destination. So to implement the pathfinding, we require a 3D map using this useful component we can also restrict the areas where the agent (user) cannot walkthrough.

B. Virtual Navigation Path

The Line Renderer component produces a straight line between two or more points in a three-dimensional space. We can draw anything with a Line Renderer, from a simple straight line to a complex spiral. Navmesh provides the shortest path using the line renderer component a virtual path is displayed on the user's screen to guide the user to its destination.

C. Floor design

For the navmesh to work properly it needs 3D meshes of the floor and marked walkable floor surfaces. It builds a graph out of it and works out the optimal paths. The 3D meshes are provided by importing floor plans into unity and manually creating walls, floor surfaces, stairs, etc. So for this project, the 2D floor plan of a 1-story building is used. After importing floor plans into unity, all the walls and building features were created on top of it and fed to navmesh. All the 3D maps layouts of the indoor environment will be already stored in the app itself.

D. Localization based on Google's AR Core

The AR Core SDK is used to follow the user's camera movement and determine their position in the virtual environment. Its movement tracking and surrounding interpretation will assist the user in moving in accordance with their camera movement. By altering scripts that are a part of the AR Core SDK we can detect the movement and pose of the camera and move the user according to the camera interaction. As the system detects movement in the camera, it updates the user's position and displays the augmented path accordingly.

E. QR codes

We have implemented our small scale model in a 1 story building which has 4 locations named as living room, kitchen, my workspace, and start point. Each location has a specific QR code to identify its location in an indoor space. These QR codes are used for re-localization if the user is lost in the indoor space while navigating. Here QR works as landmarks for localization or as location identity markers.

Fig. 2. QR Codes and the indicating destinations

VI. Result

We have divided this into two parts. The first part describes the outcome of our first version of the app and the second part describes the second version of the app. We developed a Unity application that aids in indoor localization and navigation for users that require assistance. Navigation assistance is provided using the virtual path displayed on smartphones. The user interface of this application is quite simple and user-friendly. In order to use the application, the users are required to download install the application on their device.

Fig. 3. Endpoint Destination selection from drop-down menu

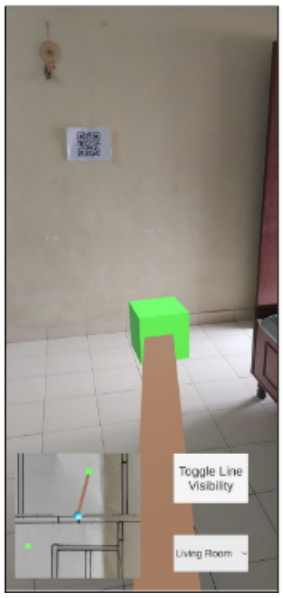

Fig. 4. AR path displayed to destination with UI interface (Line visibility button, drop-down menu)

A. Version 1

In this version, there is only one start point and one endpoint. In the UI section, there is a mini-map where users

can see their current location can toggle the AR path on off by tapping on the screen. So to start navigation users have to be present at the starting point and start the application from the start point itself for better accuracy. In the ver. 1 of the navigation app we found that when the user moves in an unknown space of the indoor structure or when the user's camera feed is blocked by the user's finger or any other obstacle then the app loses its location and is unable to identify the user's current position in indoor 3D space. This is one of the major drawbacks that we encountered. The second drawback was that the user has to always start navigation from the starting point cannot start from anywhere in the indoor architecture.

B. Version 2

In the second version of the app, we used QR code-based localization to overcome the previous drawbacks. In the UI section, there is a mini-map where users can see their current location and can toggle the AR path on off by tapping on the toggle button, the user can select the endpoint location from the dropdown displayed on the user's screen. So to use QR code localization, QR codes need to be attached at each location in the indoor structure. In this version, more destination points are added users can start navigating from any point by relocalizing the app using any QR code in that indoor space.

VII. Conclusion

The primary goal of this project was to provide a cost-effective AR indoor navigation system to people who have difficulty navigating large commercial complexes, office buildings, college campuses, and similar environments. We first created the first version using ARCore-based localization, but after discovering a few flaws and challenges, we refined our concept and created the second version, which uses QR codes. The system's quality and performance were greatly improved by combining ARCore with QR code-based technology. This combination is also an ideal substitute for BLE-based navigation systems because BLE systems require the installation of BLE beacons throughout the building, which significantly increases the system's cost. Using an AR navigation system instead of 2D maps enhances user navigation performance and reduces user workload by providing additional information about the environment around them.

VIII. Future work

AR navigation systems will have a huge impact on the world in the coming years. Every day, more functionalities are being introduced to the system. One of the useful features that we expect to add in the future is a virtual bot/guide that can walk alongside the user and guide them to their destination. And, in order to make navigation more interesting and enjoyable, we intend to add new features such as scanning image targets to obtain more information about the surrounding/objects via virtual objects. The user can obtain real-time data about his or her surroundings (for example crowded places). They can also receive emergency alerts on their mobile devices in the event of an emergency.

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